FACE UP TO THE CHALLENGE

New regulatory requirements from the Environmental Protection Agency are set to bring operating and compliance challenges to refinery flares.

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US refinery flares have a variety of new operating requirements that must be met under the revised US Environmental Protection Agency (EPA) Refinery Sector Rule (RSR) with the intention of reducing hazardous air pollutants (HAPs) emissions to the atmosphere. Historically, refineries enjoyed a startup, shutdown and malfunction (SSM) exemption, which provided relief from compliance during events that were not part of normal day-to-day operations. The updated RSR, which comes into effect on 30 January 2019, eliminates this SSM exemption and requires refinery flares to meet required operating limits,

Btu NHV calibration standards and supplemental fuel gases are designed to help meet regulatory requirements and improve process control in the refinery.

even during these previously exempt times. This creates a new set of challenges for operation and compliance, especially during planned startup and shutdown events.

New RSR regulatory requirements include, but are not limited to, flare tip velocity and combustion zone operating limits, including maintenance of minimum required net heating values (NHVs) at flare tips. The standard minimum NHV in the combustion zone (NHV_{cz}) is 270 Btu/ft^3, but this can be higher depending on the flare type, combusted materials and local permitting limits. The RSR also requires refineries to install flare monitoring equipment to demonstrate compliance with the abovementioned operating limits on a 15 min. block period, when regulated material is sent to the flare. Other industries (especially petrochemical producers) are also seeing application of similar rules to their sites in various locations.

Malfunctions

Most flares are connected to multiple process units and have the ability to receive regulated material. As this regulated material consists primarily of flammable hydrocarbons, malfunctions that result in a relief scenario to the flare will typically involve a large volume of high-Btu material, thus providing significant NHV_{cz}.

As long as the flare is not being over-assisted with steam or air, the automatic addition of supplemental gas during these large release events should not be necessary. A potential problem could arise, though, as the most common concern for dynamic control of NHV_{cz} originates from a slow system response to reduce the amount of assist gas (steam or air) supplied to the flare tip as the relief event subsides or comes to an end. Operations personnel will have likely been required to take an automated steam to vent gas (S/VG) control system into manual mode and add additional assist gas to correct a smoking flare event. While the personnel are busy responding to the malfunction to ensure safe operation of the affected process unit, they could forget to switch the S/VG control system back from manual to automatic. This could, in turn, result in an over-assisted flare.

An over-assisted condition would then require the addition of supplemental gas to boost the NHV_{cz} and remain in compliance with the new standard.

Potential fuel supply issues can arise based on the type of malfunction and the unit that is affected. If a process unit or area of the facility that is a large producer of refinery fuel gas has to curtail or cease operation, the refinery fuel gas system will be absorbing a greater amount of natural gas, which could reduce the overall fuel system's ability to supply sufficient natural gas. This potential strain on or redirection of the external natural gas supply could also limit the ability to properly control other refinery site flares if the upset is widespread.

The startup and shutdown challenge

Planned startup and shutdown events are typically associated with turnarounds and major maintenance or construction activities. These events usually include purging, cooling and/or heating of vessels and equipment with either nitrogen or steam to make the equipment 'hydrocarbon free'. Other typical maintenance events can include large volumes of nitrogen or steam used to purge catalyst or dryer beds to maintain an inert environment. Materials purged from the vessels can include volatile organic compounds (VOCs) and HAPs, and these waste gases are commonly routed to the flare as an emissions control device. As previously noted, the revised RSR requires that flares maintain NHV_{cz} even during purge events due to elimination of the SSM exemption. During various phases of these purge events, the flare gas stream has the potential to be predominantly inert and will not meet the required NHV_{cz} operating limit. Supplemental fuel gas will need to be added during these events to boost Btu levels and remain compliant.

The challenges to supplying the required supplemental gas can be estimated by reviewing the events where the largest amounts of nitrogen are utilised and determining the rate of the purge. That review frequently leads to the realisation that the required supplemental gas demand for these short periods of duration may exceed the refinery's ability to supply gas through the normal existing supplemental gas line. Refineries must then choose between slowing down purge flow rates or increasing the available fuel gas supply to the flare. Slowing down purge flow rates extends the time required to perform maintenance, consequently adding project cycle time and process unit downtime.

These direct and opportunity cost impacts drive a search for other means of achieving compliance. One such alternative would be to route the waste gas stream to a thermal oxidiser instead of a flare during major planned events to ensure destruction of HAPs. Factors to take into consideration while planning for such a change would include costs associated with infrastructure modification, setup, and space restrictions, to name a few.

More frequently, refineries are considering the addition of supplemental fuel gas to their flare steams to boost Btu/ft^3 NHV_{cz} to required levels. Supplemental fuel gas options can be categorised into either internal or external sources.

Internal supplemental fuel gas

Internal source options typically include modifying infrastructure piping, valves and control systems to route existing onsite fuel gas sources to flare feed lines. This can be done by increasing the size of natural gas supply lines, or piping in existing process gases (such as hydrogen or process generated waste gas streams, typically used in the plant for feed to fired heaters and boilers, etc.).

The use of these gases will depend on their availability. In some cases, the utility supply of natural gas to a site is simply not high enough to meet the NHV_{cz} operating limit when flowing purge nitrogen at

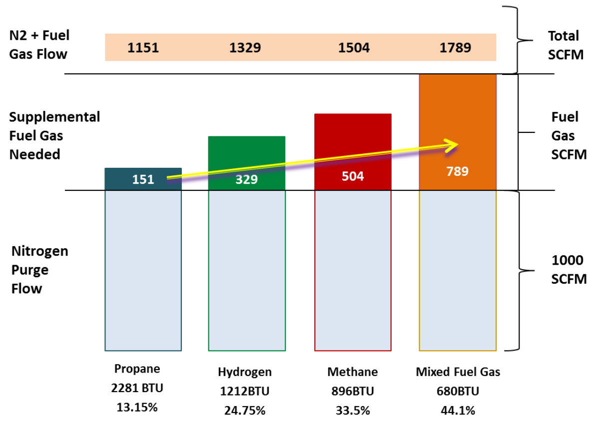

Figure 1. The gas ratio required for 300 Btu in flare line per 1000 ft^3 of nitrogen purge flow with low flammable content.

thousands of standard cubic feet per minute. As the RSR allows the use of 1212 Btu/ft^3 for calculating hydrogen NHV_{cz}, if specifically monitored, excess hydrogen can provide more Btu/ft^3 into the calculation than natural gas. One must consider availability of the supplemental gas during periods of maintenance when considering this option. If the supply lines to the facility as a whole cannot supply the worst-case scenario rates to the flare and the other sources in the facility, that particular gas will not be a viable option to be used as supplemental fuel.

Additionally, flares are not typically located close to existing process units due to thermal radiation concerns. Therefore, the length of the new piping can be costly, especially if new pipe rack supports need to be constructed. Factors to consider when evaluating infrastructure upgrades include the available line sizes and pressures supplied to the facility, as well as the distance to those larger lines or sources.

These internal options can all be valid, but are not always the most cost-effective alternative or available in sufficient volume to prevent a purge flow from slowing down. Infrastructure additions can also generate significant capital expense demands for systems that are typically only used on a sporadic and planned basis which lowers their investment favourability.

External supplemental fuel gas

The addition of temporary external supplemental fuel gas (ESFG) is being considered at facilities seeking options to address feasibility and cost challenges. As most events that utilise nitrogen to purge are planned events, the need to add propane, butane or other supplemental gas during these periods can also be planned. This allows for supply systems to be customised for specific project demands, while potentially allowing for purge operation at the required levels with minimal infrastructure investment. ESFG systems can be installed completely in lieu of internal sources or added for use on a truly supplemental project basis to boost internal source NHV_{cz} and help ensure compliance.

Primary considerations for ESFGs use include anticipated purge gas flow rates, pressures and impacts from steam or air assist at flare tips so flare feed lines and connections can be properly sized and placed for the chosen fuel gas. Vaporisation, pumping, control and regulating systems will be based on these factors and the integration of EPA-compliant flow monitoring equipment and outputs within the supply system can be a significant asset for project control and reporting.

Selecting the optimum fuel gas for the application is also critical as this can greatly impact both feed and control system design and project operating costs. Gas selection can also impact smoking, which would increase steam or air assist requirements. Fuel gas product and supply system availability, along with purge gas supply coordination, can be critical to effective project execution and compliance.

The flare must also comply with the flare exit velocity limits and these must be considered when making the choice of which external supplemental fuel gas to use for a given application. During an event that would have experienced elevated exit velocities, the need to add supplemental fuel will make it more difficult to comply. Choosing a gas that has the highest Btu content will lead to the least amount of supplemental gas added and help avoid inadvertently exceeding the flare tip velocity threshold.

Figure 1 shows approximate required supplemental addition flows per 1000 ft^3 of nitrogen in a purge stream based on the Btu/ft^3 of various fuel gases, including potentially lower heat level internal sources encountered in some sites.

The use of higher Btu/ft^3 external supplemental fuel gas also eases project operation logistics and costs by reducing the amount of gas needed to meet NHV_{cz} requirements, thereby extending the time between delivery resupply operations. A pre-engineered, packaged external supplemental fuel gas system for gas supply, vaporisation, control and monitoring can possibly help provide simplified, plug and play project-based compliance simplification, while reducing overall project costs.

Conclusion

Removal of the SSM exemptions in the updated RSR will lead to additional compliance-related considerations during turnarounds and major project events. It will be critical for petroleum refineries and other collaterally affected sites to review their flaring estimates to determine the periods of highest supplemental gas demand and evaluate whether existing systems or new sources of supplemental gas can best help with ensuring ongoing compliance. Evaluation of the best applicable means of supply for individual flares will inevitably be based on a combination of factors, including feasibility, project complexity, as well as capital investment requirements and returns. Direct and opportunity cost impacts must also be weighed with final decision making, ultimately favouring the option that provides greatest overall financial benefits. HE